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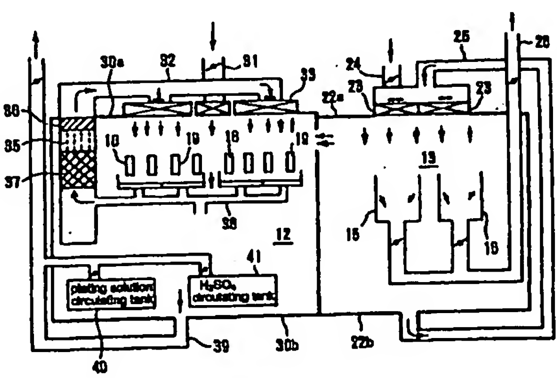
(54) **SUBSTRATE PLATING DEVICE**

(57) An object of the present invention is to provide a substrate plating apparatus capable of performing continuous plating operations within one apparatus without the wafers becoming contaminated after the post-plating process by chemicals used in the plating process and the like. Further object is to provide a substrate plating apparatus capable of forming a plating film of uniform thickness on the plating surface of the wafer, while encouraging bubbles to escape from fine holes or grooves in the substrate surface and deterring particles from depositing on the plated surface. According to the present invention, there is provided a substrate plating apparatus for continuously performing a plating process and post-plating process within the same apparatus, the substrate plating apparatus comprising a contaminated zone within which the plating process is performed; a clean zone within which the post-plating process is performed; and a partition dividing the apparatus into the contaminated zone and the clean zone, wherein each zone is independently ventilated. A substrate plating apparatus for plating a surface of a substrate with a plating solution comprises a plating bath that is hermetically sealed and accommodates the substrate to be plated; and a flow path of the plating solution being formed to

FIG. 5



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required, and each zone has an independent method for treating particles. Accordingly, the invention can prevent the chemical mist and vapor from depositing on the substrate after completion of the post-process.

[0012] According to another aspect of the present invention, the partition is provided with a shutter that can be opened and closed. Hence, the substrate can be transferred between the contaminated zone and clean zone before conducting the preprocess or after conducting the plating process by opening the shutter provided in the partition.

[0013] According to another aspect of the present invention of the substrate plating apparatus, an air flow in the contaminated zone comprises of circulating flow circulating therein and supplied and discharged flow which is supplied externally into the contaminated zone and is discharged externally, thereby the circulating flow flows downward as clean air from the ceiling of the apparatus through the contaminated zone and, after a scrubber and/or mist separator remove chemical mist or vapor of solution from the circulating flow, cycles back into the contaminated zone from the ceiling of the apparatus as clean air.

[0014] With this construction, a sufficient amount of clean air can be supplied to the contaminated zone and particles can be prevented from contaminating the processed substrate while minimizing the amount of air flow that is supplied from an external source and exhausted.

[0015] According to another aspect of the present invention, the substrate plating apparatus further comprises conveying devices provided one in each of the clean and contaminated zones for conveying a substrate through the zones, each having a hand portion for retaining the substrate; and a coarse washing chamber disposed adjacent to the partition for coarsely washing the substrate while being retained by the hand portion of the conveying device disposed in the contaminated zone after the plating process has been completed.

[0016] With this construction, the hand portion of the conveying device disposed in the contaminated zone is washed along with the processed substrate. Hence, the invention can prevent contaminants from the plating solution deposited on the hand portion from being transferred onto the conveying device in the clean zone.

[0017] According to another aspect of the present invention, a method for plating a substrate by continuously performing a plating process and post-plating process within the same apparatus, comprises: partitioning the inside of the plating apparatus to form a contaminated zone and a clean zone, each zone being independently ventilated; disposing a conveying device in each of the clean and contaminated zones for conveying a substrate through the zones; disposing a coarse washing chamber adjacent to the partition; and coarsely washing the substrate while the same is retained by a hand portion of the conveying device disposed in the contaminated zone.

[0018] With this method, the hand portion of the conveying device disposed in the contaminated zone is washed along with the processed substrate. Hence, it is possible to remove plating solution deposited on the hand portion and prevent chemical mist and vapor from being introduced into the clean zone.

[0019] According to another aspect of the present invention, the method for plating a substrate further comprises the steps of withdrawing the hand of the conveying device after the coarse washing process is completed, coarsely washing the substrate again by itself, and subsequently conveying the substrate into the clean zone. With this method, it is possible to more effectively prvent chemical mist and vapor from being introduced into the clean zone.

[0020] According to another aspect of the present invention, a substrate plating apparatus for plating the surface of a substrate with a plating solution comprises a plating bath that is hermetically sealed and accommodates the substrate to be plated; and a flow path of the plating solution being formed to be parallel to the surface of the substrate. Since the plating solution flows parallel to the substrate surface, a more uniform plating layer can be formed on the surface of the substrate.

[0021] According to another aspect of the present invention, the substrate is maintained such that its surface is slanted in relation to the vertical plane. This construction prevents particles from depositing on the surface of the plated substrate.

[0022] According to another aspect of the present invention, the substrate plating apparatus further comprises a retaining device for retaining the substrate such that its surface is slanted from the vertical plane within a range of 30 degrees from vertical while the plating process is performed. With this construction, air bubbles can be easily dislodged from fine holes formed in the plating surface and plating solution can flow into the interior of the fine holes to form a plating layer on this interior surface. Further, particles do not deposit on the surface of the substrate.

[0023] According to another aspect of the present invention, a method for plating the surface of a substrate with a plating solution, comprising: disposing a substrate to be plated within a hermetically sealed plating bath; introducing the plating solution into the plating bath; and plating the surface of the substrate while varying the pressure of the plating solution and changing the direction of the flow. With this method, a dense plating layer can be formed in fine grooves formed in the substrate surface.

[0024] According to another aspect of the present invention, the plating solution flows parallel in relation to the surface of the substrate and the width and length of the flow path of the plating solution are larger than the diameter of the substrate. Since the plating solution flows parallel to the surface of the substrate, a plating layer of uniform thickness can be formed on the plating surface.

[0025] According to another aspect of the present invention, the plating bath comprises a main section having an

Fig. 12 is an enlarged cross-sectional view indicated by the arrows D-D in Fig. 10;

Fig. 13 is a cross-sectional view showing the construction of a conventional plating bath;

Fig. 14 is a cross-sectional view showing the construction of a conventional plating bath;

Figs. 15A-15C are views, which explain the concept of the plating bath according to the present invention;

Fig. 16 shows an example of the construction of the plating apparatus having a plating bath according to the present invention;

Fig. 17 is a front cross-sectional view of the plating bath in Fig. 16 indicated by the arrows B-B in Fig. 16;

Figs. 18A-18B show another example of the construction of the plating bath used in the plating apparatus of the present invention, with Fig. 18A a side cross-sectional view of the plating bath and Fig. 18B an enlarged view of the area indicated by B in Fig. 18A;

Fig. 19 is a plan view showing the construction of the side plate used in the plating bath of the plating apparatus shown in Fig. 18;

Fig. 20 shows the construction of a cover mechanism on the plating bath used in the plating apparatus of Fig. 18;

Fig. 21 shows the construction of a cover mechanism on the plating bath used in the plating apparatus of Fig. 18;

Fig. 22 shows the construction of a wafer mounting mechanism used in the plating apparatus of Fig. 18;

Fig. 23 shows the construction of a wafer mounting mechanism used in the plating apparatus of Fig. 18;

Fig. 24 shows another example of the construction of the plating bath used in the plating apparatus of the present invention;

Fig. 25 is a cross-sectional view showing a plating bath for automatically analyzing components in the plating solution; and

Fig. 26 is an explanatory diagram showing the concept of the device for automatically analyzing and displaying information about components in the plating solution.

Best Mode for Carrying Out the Invention

[0036] A substrate plating apparatus according to preferred embodiments of the present invention will be described while referring to the accompanying drawings.

[0037] A substrate plating apparatus according to the present embodiment performs a copper plating on the surface of a semiconductor substrate (wafer) in order to obtain a semiconductor device having wiring formed of the copper layer. This process is described with reference to Figs. 1A-1C.

[0038] As shown in Fig. 1A, a semiconductor wafer W is comprised of a semiconductor material 1, a conductive layer 1a formed on the top surface of the semiconductor material 1, and an SiO_2 insulating layer 2 deposited on top of the conductive layer 1a. A contact hole 3 and a groove 4 are formed in the insulating layer 2 by a lithography and etching technique. A barrier layer 5, such as TiN, is formed over the surfaces in the contact hole 3 and groove 4.

[0039] By performing a copper plating process on the surface of the semiconductor wafer W, a copper layer 6 is deposited so that the contact hole 3 and groove 4 are filled with copper and as well deposited on the top of the insulating layer 2. Next, chemical mechanical polishing (CMP) is performed to remove the copper layer 6 from the top of the insulating layer 2. This process is necessary to form the surface on the copper layer 6 filling the contact hole 3 and groove 4 to be approximately flush with the surface of the insulating layer 2. As a result, the copper layer 6 forms wiring, as shown in Fig. 1C.

[0040] Next, a plating apparatus for performing electrolytic copper plating on the surface of the semiconductor wafer W will be described with reference to Fig. 2. As shown in the diagram, the plating apparatus is provided in a rectangular shaped equipment 10 and configured to perform continuous copper plating of semiconductor wafers W. The equipment 10 is provided with a partition 11 to divide the equipment 10 into a contaminated zone 12 and a clean zone 13. The contaminated zone 12 and clean zone 13 are configured to be ventilated independently. The partition 11 is provided with a shutter (not shown) that can be opened and closed freely. The pressure within the clean zone 13 is set higher than that within the contaminated zone 12. Further, the apparatus is configured such that the air from the contaminated zone 12 does not flow into the clean zone 13.

[0041] The clean zone 13 includes a loading unit 14a and an unloading unit 14b for accommodating wafer storage cassettes, two each of a washing device 15 and drying device 16 for performing post-plating processes, and a conveying device (conveying robot) 17 for conveying wafers within the clean zone 13. The washing device 15 can be either a pencil-type device with a sponge attached to the end or a roller-type device with an attached sponge. The drying device 16 dries the wafer by spinning it at a high rate of speed.

[0042] The contaminated zone 12 is provided with preprocessing baths 18 for performing a preprocess on the substrate, plating baths 19 for performing a copper plating process, and a conveying device (conveying robot) 20 for transporting the wafers within the contaminated zone 12. Each of the preprocessing baths 18 accommodates a preprocess solution containing sulfuric acid or the like. The preprocess is performed by immersing the wafer into the preprocess solution. Each of the plating baths 19 accommodates a plating solution containing copper sulfate. The copper plating

of an open-ended rectangle and a rectangular shaped cover 51 capable of freely opening and closing over the front open portion of the main section 50. By closing the front open portion of the main section 50 with the cover 51, a plating chamber 52 is formed within the main section 50 to enable plating solution to flow in the up-down direction at an angle θ from the vertical plane. This angle θ is set within a range of 0-30°.

[0054] A packing seal 53 is mounted on the peripheral edge of the main section 50 in order to maintain a waterproof seal when the cover 51 is closed over the main section 50. The cover 51 is configured to detachably retain a wafer W on its underside surface. Further, a sensor (not shown) is provided on the inner side of the cover 51 to detect the existence of the semiconductor wafer W.

[0055] A depression 50a is formed in the main section 50. A flat anode 54 is mounted inside the depression 50a and parallel to the plating chamber 52. A shielding plate 55 formed of a dielectric plate is disposed on the open end of the depression 50a. An opening 55a is formed on the interior of the shielding plate 55 for adjusting the electric field on the plating surface of the semiconductor wafer W.

[0056] An upper header 56 and a lower header 57 are mounted on the up and down ends of the main section 50 respectively. The upper header 56 and lower header 57 are in fluid communication with the plating chamber 52 via a plurality of through-holes 56a and 57a respectively. The upper header 56 and lower header 57 alternately introduce plating solution into the plating chamber 52 and discharge plating solution from the plating chamber 52.

[0057] With this construction, the cover 51 is opened to mount a semiconductor wafer W that is retained on the backside surface of the cover 51. Then, the cover 51 is closed. In this state, a plating solution is introduced either from the upper header 56 or lower header 57 into the plating chamber 52 and discharged from the other. A plating process is performed on the semiconductor wafer W, while the flow of plating solution is reversed at fixed intervals. With this method, air bubbles can be easily dislodged from within fine grooves on the surface of the semiconductor wafer W, thereby increasing the uniformity of the plating layer. At the same time, the required installation area for the plating baths 19 inside the apparatus is decreased, enabling more plating baths 19 to be disposed in a small equipment space.

[0058] In the plating baths 19, cleaning solution is introduced into the plating chamber 52 and discharged via the upper header 56 and lower header 57 for washing the semiconductor wafer W after the plating process. A gas for drying the semiconductor wafer W, such as N_2 gas, dry air, or the like is introduced and discharged in the same way, enabling the wafer W to be dried after the washing process.

[0059] Next, a second embodiment of the present invention will be described with reference to Figs. 8-12. In the present embodiment, the rectangular equipment 10 is divided by the partition 11 into the contaminated zone 12 and the clean zone 13. Air can be supplied and discharged independently to the contaminated zone 12 and the clean zone 13 and the internal pressure of the clean zone 13 is set higher than the pressure in the contaminated zone 12.

[0060] The clean zone 13 houses the loading unit 14a and unloading unit 14b, two washing and drying units 60 for performing post-plating processes, and a conveying device (conveying robot) 61 for conveying wafers. The contaminated zone 12 houses preprocessing baths 18 for performing a pre-plating process on the wafer W, the plating baths 19 for performing the plating process, and a conveying device (conveying robot) 62 for conveying wafers.

[0061] The plating baths 19 and preprocessing baths 18 are constructed in the same way as described in the first embodiment. The conveying device 62 can be a six-axis robot, for example, as shown in Fig. 9. The conveying device 62 is provided with a plurality of arms 63, a freely opening and closing hand 64 mounted on the end of each arm 63, and a plurality of rollers 65 rotatably supported on the inner surface of the hand 64.

[0062] A loading stage 67 is provided in the clean zone 13 adjacent to the partition 11. The loading stage 67 has a plurality (four in the diagram) of support bases 66. With this construction, unprocessed wafers W retained by the conveying device 61 in the clean zone 13 are loaded on the support bases 66 in the loading stage 67. Subsequently, the conveying device 62 in the contaminated zone 12 extracts the wafer W resting on the support bases 66.

[0063] A partitioning plate 70 (see Fig. 10) is disposed between the loading stage 67 and the partition 11. The partitioning plate 70 is provided with an opening 70a through which the hand 64 of the conveying device 62 is inserted, a cylinder 71, a shutter 72 that opens and closes the opening 70a by means of the cylinder 71. The partition 11 is also provided with an opening 11a through which the hand 64 of the conveying device 62 passes.

[0064] With this construction, the shutter 72 is opened when the conveying device 62 in the contaminated zone 12 is extracting a wafer W from the support bases 66 and is closed at all other times.

[0065] A coarse washing chamber 83 is provided adjacent to the partition 11 and in a position parallel to the loading stage 67. The coarse washing chamber 83 has a box-shape and is formed from a rear partition plate 80 that is integrally formed with the partitioning plate 70, a front partition plate 81 surrounding the front part of the rear partition plate 80 in the shape of an open rectangle, and a ceiling plate 82. The coarse washing chamber 83 houses an unloading stage 85 with the same construction as the loading stage 67 described above. The unloading stage 85 includes a plurality (four in this diagram) of support bases 84.

[0066] A plurality of ejection nozzles 86 are provided on the inside top and bottom of the coarse washing chamber 83 for ejecting cleaning solution (see Fig. 12). The rear partition plate 80 is provided with an opening 80a through which the hand 64 of the conveying device 62 is inserted, a cylinder 87, and a shutter 88 for opening and closing the opening

[0077] Figs. 15A-15C are explanatory diagrams showing the concept of the plating bath according to the present invention. As shown in Fig. 15A, the plating bath includes a plating jig 201 and a substrate 202 mounted on the jig 201 with the plating surface in a vertical orientation. A plating solution 203 flows in parallel to the plating surface from bottom to top.

[0078] By supplying the plating solution 203 in a flow parallel to the surface of the substrate 202 within a hermetically sealed plating bath, it is possible to form a uniform plating layer on the surface of the substrate 202. The approximate vertical orientation of the substrate 202 prevents the problem of particles depositing in the plating on the surface of the substrate 202. It is also possible to prevent such particle deposition by tilting the substrate slightly from vertical, as shown in Fig. 15B. The substrate shown in Fig. 15B is tilted with its plating surface facing upward. However, it is also possible to tilt the substrate so its plating surface is facing downward with the same effects.

[0079] By tilting the substrate 202 from the vertical plane so that its surface is facing upward, as shown in Fig. 15B, an air bubble 204 can easily escape from a hole 202a formed in the substrate 202, as shown in FIG. 15C. Hence, particles will not be deposited on the plating surface of the substrate 202 when the substrate 202 is tilted off the vertical plane, as shown in FIG. 15B. Further, by flowing the plating solution 203 parallel to the plating surface of the substrate 202, it is possible to form a plating layer having uniform thickness on the surface of the substrate 202 without being affected by the size of the substrate 202.

[0080] It is desirable to tilt the substrate at an angle of 0-45° from the vertical plane, whether facing upward or facing downward, in order to best prevent particle deposition and allow air bubbles to escape. If the substrate is facing upward, it is even more desirable to set the angle of tilt from the vertical plane to 0-30°. It is effective to slant the substrate with the surface facing downward when it is possible to avoid the adverse effects of air bubbles by controlling the pressure and flow of the plating solution and the like.

[0081] Since the plating solution flows parallel to the plating surface in a sealed space, it is possible to adjust the pressure of the plating solution, as well as the direction and rate of flow. With this method, a plating layer can be densely formed in fine grooves formed in the surface of the substrate.

[0082] Fig. 16 shows an example construction of a plating apparatus 210 according to the present invention. Fig. 17 shows a cross-section along the front part of the plating apparatus indicated by the arrows B-B in Fig. 16. The plating apparatus 210 includes a plating bath 211, an upper header 212 and a lower header 213 disposed on the top and bottom of the plating bath 211 respectively, a pump 214, a constant-temperature unit 215, and a filter 216. The plating bath 211 is formed of a main bath section 217 having a cross section shaped as an open-ended rectangle and a flat side plate 218. A substrate 219 is mounted on the side plate 218. A packing 220 is provided to sealingly contact the peripheral edge of the substrate 219 when the side plate 218 sealingly contacts the opening portion of the main bath section 217. A flat anode 221 is provided on the main bath section 217 and disposed parallel to the substrate 219. The plating bath 211 shown in Fig. 16 is the cross section indicated by the arrows A-A in Fig. 17.

[0083] A shielding plate 222 formed of a dielectric plate is disposed between the anode 221 and substrate 219. A hole 222a is formed in the center portion of the shielding plate 222 opposite the plating surface of the substrate 219. The hole 222a serves to adjust the electric field that has the effect of adjusting the electric field on the plating surface of the substrate 219. The substrate 219 and shielding plate 222 are positioned parallel to each other, forming a space therebetween, through which a plating solution 223 flows. The flow path is formed in the space such that the plating solution 223 flows parallel in relation to the plating surface of the substrate 219. The width b and length c of the flow path of the plating solution is larger than the diameter a of the substrate 219. A plurality of holes 217a and 217b are formed in the top and bottom of the main bath section 217 to allow plating solution to flow through the main bath section 217. A DC power source 224 applies a prescribed voltage between the anode 221 and substrate 219.

[0084] When plating solution flows in the forward direction through the plating bath 211 in the plating apparatus 210 described above, valves V1 and V4 are opened and valves V2, V3, V5, and V6 are closed. Plating solution 223 stored in a circulating tank 225 is transferred by the pump 214 to the upper header 212 via the constant-temperature unit 215, filter 216, a current regulating valve 226, and the valve V1. The plating solution 223 passes through the plating bath 211, the lower header 213, and the valve V4 and returns again to the circulating tank 225. Within the plating bath 211, the plating solution 223 flows through the holes 217a of the main bath section 217, the space formed between the substrate 219 and shielding plate 222, and the holes 217b on the bottom of the main bath section 217. The power source 224 applies a prescribed voltage between the anode 221 and substrate 219. Accordingly, it is possible to adjust the direction and rate of flow and the pressure of the fluid to desirable values.

[0085] In the plating apparatus described above, the substrate 219 is fixed to the side plate 218 of the plating bath 211. Therefore, by positioning the plating bath 211 along the vertical plane or tilted from the vertical plane, the substrate 219 will also be positioned accordingly. A desirable tilt angle is 0-45° or even more desirable 0-30°, but is not limited to this range. Accordingly, air bubbles can easily escape from the fine holes formed in the plating surface and particles do not deposit on the surface of the wafer. Further, when the plating solution 223 flows in the gap between the substrate 219 and shielding plate 222, the flow is parallel in relation to the plating surface of the substrate 219, as described above. Accordingly, a plating layer of uniform thickness can be formed on the surface of the substrate 219 without being

bracket 232 D_1, and the inner diameter of the packing 220 D_2, then the force pushing the packing 220 on the substrate 219 side can be calculated by $P \times (D_1^2 - D_2^2)\,\pi/4$. This force improves the sealing ability of the packing 220. By setting the internal force of the plating bath 211 higher than the external force (atmospheric pressure), the end of the inner peripheral edge on the packing 220 presses forcefully against the peripheral edge of the substrate 219, forming a strong seal.

[0095] As shown in Figs. 18A, 18B, and 19, the electrodes 230 are provided on the outside of the packing 220. Since the electrodes 230 contact the substrate 219 at a point outside of the sealed area, where the inner peripheral edge of the packing 220 contacts the peripheral edge of the substrate 219, the electrodes 230 does not contact the plating solution and is not plated. Therefore, it is possible to prevent particles from being generated from the electrodes 230. At the same time, the electrodes 230 can maintain a stable conductivity.

[0096] Figs. 20 and 21 show the construction of a bath cover mechanism for the plating bath 211. The bath cover mechanism includes a cover member 235. The side plate 218 is pivotally supported on the cover member 235 by a bracket 242 and a pin 243. The bottom end of the cover member 235 is pivotally supported on the bottom end of the main bath section 217 by a hinge mechanism 237. A cylinder 238 is provided for opening and closing the cover member 235 and includes a piston 238a. The end of the piston 238a is pivotally supported on the pin 243. By operating the cylinder 238, the piston 238a advances and retracts, causing the cover member 235 to rotate about the hinge mechanism 237. The side plate 218 supported on the cover member 235 rotates to open and close the plating bath 211.

[0097] A support member 241 is attached to the top portion of the main bath section 217. A locking cylinder 234 is provided on the support member 241 and has a piston 234a. A locking member 236 is coupled with the piston 234a. Operating the cylinder 238 to advance the piston 238a rotates the cover member 235 and side plate 218 until the side plate 218 contacts the main bath section 217. By operating the locking cylinder 234, the locking member 236 protrudes and engages with a locking protrusion 239 provided on top of the cover member 235, thereby locking the cover member 235 and side plate 218, as shown in Fig. 21.

[0098] A hinge mechanism 240 links the side plate 218 and cover member 235 and functions to adjust a margin between the two members to a prescribed amount. This amount of margin is adjusted by a nut 240a to set the distance from the point that the substrate 219 contacts the packing 220 until the side plate 218 is locked.

[0099] When the cover member 235 is in the open position indicated by the arrow C in Fig. 20, the substrate 219 is mounted on the side plate 218. Figs. 22 and 23 show the construction of the wafer mounting mechanism. As shown in these diagrams, the wafer mounting mechanism includes a pawl drive cylinder 244 fixed to the side plate 218 and having a piston 244a. A wafer retaining pawl 245 is fixed to the end of the piston 244a and protrudes over the top surface of the side plate 218. A wafer retaining pawl 246 protrudes under the bottom surface of the side plate 218 via a spring or the like (not shown).

[0100] A rod 250 is fixed to the bottom end of the pawl drive cylinder 244. A sliding member 249 is provided freely and slidingly on the rod 250 via a spring 251. A roller 247 is rotatably fixed on one end of the sliding member 249. A pawl pushing member 248 is linked to the other end of the sliding member 249 via a coupling member 252 for pushing the wafer retaining pawl 246. The pawl pushing member 248 is rotatably supported on a pin 253 serving as a pivot point. A contact member 254 is contacted by the roller 247.

[0101] In the wafer mounting mechanism described above, the cylinder 238 of Fig. 20 is operated to open the side plate 218 as shown in Fig. 23. At this time, the roller 247 contacts the contact member 254, thereby pushing up the sliding member 249. This pulls up on the end of the pawl pushing member 248 via the coupling member 252 and rotates the pawl pushing member 248 clockwise about the pin 253, pushing against the wafer retaining pawl 246. The pawl pushing member 248 forces the wafer retaining pawl 246 to protrude exactly a prescribed distance from the surface of the side plate 218. Next, by operating the pawl drive cylinder 244, the wafer retaining pawl 245 is moved upwardly at prescribed distance. At this state, distance between the wafer retaining pawls 245 and 246 is larger than the diameter of the substrate 219 by a prescribed length.

[0102] At this point, the substrate 219 gripped by the front end of the robot arm is put on the upper surface of the side plate 218 between the wafer retaining pawls 245 and 246. The sensor 233 (see Fig. 18A) detects that the substrate is set on the side plate 218. By operating the pawl drive cylinder 244, the wafer retaining pawl 245 is moved until contacting the side edge of the substrate 219, and the substrate 219 is gripped between the wafer retaining pawl 246 and wafer retaining pawl 245. At this point, the substrate 219 is mounted on top of the side plate 218.

[0103] Next, the cylinder 238 of Fig. 20 is operated to extend the piston 238a. As the piston 238a extends, the cover member 235 rotates in the counterclockwise direction about the hinge mechanism 237. The side plate 218 also rotates in association with the cover member 235 in the counterclockwise direction. Accordingly, the roller 247 separates from the contact member 254, and the urging force of the spring 251 drops the sliding member 249 and coupling member 252 down a prescribed distance. This enables the pawl pushing member 248 to rotate counterclockwise about the pin 253, thereby releasing the wafer retaining pawl 246. The wafer retaining pawl 246 recedes to its original position, protruding from the surface of the side plate 218 only enough to support the outer edge of the substrate 219.

[0104] As described above, the side plate 218 closes over the opening of the main bath section 217. At this time,

automatically analyzes the components of the plating solution 310.

[0115] A cleaning solution line 326 for supplying cleaning solution to the titration cell 321, a calibrating solution line 327 for supplying calibrating solution, and a discharge line 328 are all connected to the titration cell 321. Accordingly, after the analysis is completed, the analyzed plating solution (waste solution) is discharged through the discharge line 328. Subsequently, cleaning solution and calibrating solution are supplied to the titration cell 321 through the cleaning solution line 326 and calibrating solution line 327 to clean and calibrate the inside of the titration cell 321.

[0116] A display 330 is provided for displaying results of the automatic analysis by the analyzer 322. In addition to results of the analysis, items displayed on the display 330 include titration amounts added from the pure water line 323, reagent A line 324, and reagent B line 325. Based on this data, it is possible to predict changes in the components and maintain the plating solution at a proper composition by replenishing components that are lacking.

[0117] The plating solution in the example above is electrolytic copper plating solution for an electrolytic plating process and an electroless copper plating solution for an electroless plating process. The composition of these plating solutions is shown in Table 1 below.

[Table 1]

An Example of Plating Solution Compositions and Injected Chemical Types (Basic Specifications)

Plating Method / Elements, ions, chemical types, components, etc.	Electrolytic	Electroless
(Copper) $CuSO_4 \cdot 5H_2O$ (mol/l)	0.3	0.04
Sulfuric acid (mol/l)	1.83	
Additive * (ml/l)	10	
Chlorine ions ** (mol/l)	1.7×10^{-3}	
EDTA *** • 4Na (Ethylene-diamin-tetraacetic acid • natrium) (mol/l)		0.08
27% TMAH**** tetra-methyl-ammonium hydroxide (ml/l)		56
Formalin **** (mol/l)		0.1
Water	Remainder	Remainder

Claims

1. A substrate plating apparatus for continuously performing a plating process and post-plating process within the same apparatus, the substrate plating apparatus comprising:

   a contaminated zone within which the plating process is performed;
   a clean zone within which the post-plating process is performed; and
   a partition dividing the apparatus into the contaminated zone and the clean zone, wherein each zone is independently ventilated.

2. A substrate plating apparatus as claimed in claim 1, wherein the partition is provided with a shutter that can be opened and closed.

3. A substrate plating apparatus as claimed in claim 1, wherein an air flow in the contaminated zone comprises of circulating flow circulating therein and supplied and discharged flow which is supplied externally into the contaminated zone and is discharged externally, thereby the circulating flow flows downward as clean air from the ceiling of the apparatus through the contaminated zone and, after a scrubber and/or mist separator remove chemical mist or vapor of solution from the circulating flow, cycles back into the contaminated zone from the ceiling of the apparatus as clean air.

4. A substrate plating apparatus as claimed in claim 1, further comprising:

   conveying devices provided one in each of the clean and contaminated zones for conveying a substrate through the zones, each having a hand portion for retaining the substrate; and
   a coarse washing chamber disposed adjacent to the partition for coarsely washing the substrate while being retained by the hand portion of the conveying device disposed in the contaminated zone after the plating process has been completed.

5. A method for plating a substrate by continuously performing a plating process and post-plating process within the same apparatus, the method comprising:

   partitioning inside of the plating apparatus to form a contaminated zone and a clean zone, each zone being independently ventilated;
   disposing a conveying device in each of the clean and contaminated zones for conveying a substrate through the zones;
   disposing a coarse washing chamber adjacent to the partition; and
   coarsely washing the substrate while the same is retained by a hand portion of the conveying device disposed in the contaminated zone.

6. A substrate plating apparatus for plating a surface of a substrate with a plating solution, comprising:

   a plating bath that is hermetically sealed and accommodates the substrate to be plated; and
   a flow path of the plating solution being formed to be parallel to the surface of the substrate.

7. A substrate plating apparatus for plating a surface of a substrate with a plating solution, comprising a plating bath that is hermetically sealed and accommodates the substrate to be plated, wherein the substrate is maintained such that its surface is slanted in relation to the vertical plane.

8. A substrate plating apparatus as claimed in claims 6, wherein the substrate is retained such that its surface is slanted facing upwardly from the vertical plane within a range of 30 degrees while the plating process is performed.

9. A method for plating the surface of a substrate with a plating solution, comprising:

   disposing a substrate to be plated within a hermetically sealed plating bath;
   introducing the plating solution into the plating bath; and
   plating the surface of the substrate while varying the pressure of the plating solution and changing the direction of the flow.

FIG. 1A

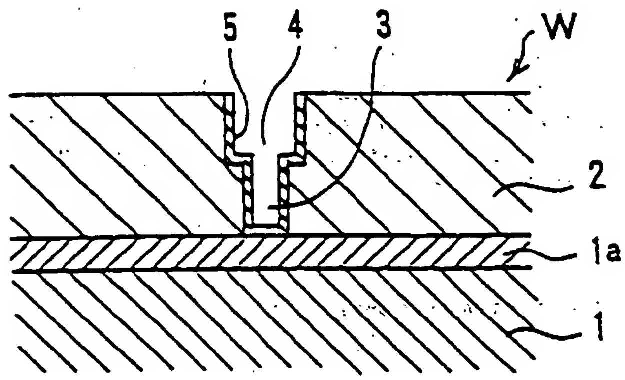


FIG. 1B

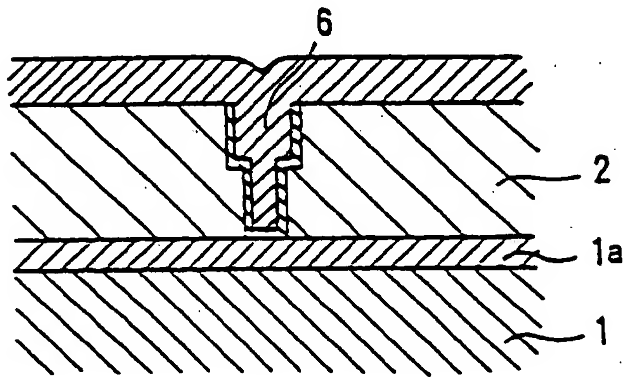


FIG. 1C

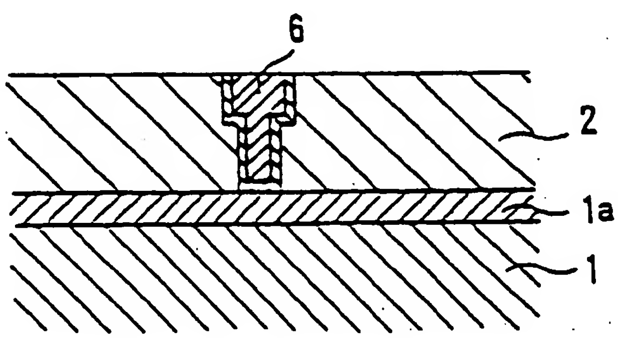


FIG. 3

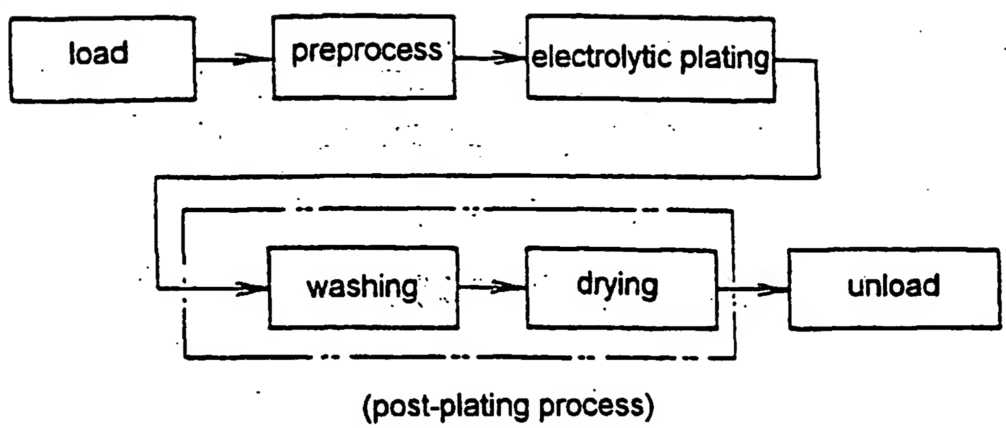

load
preprocess
electrolytic plating
washing
drying
unload
(post-plating process)

FIG. 4

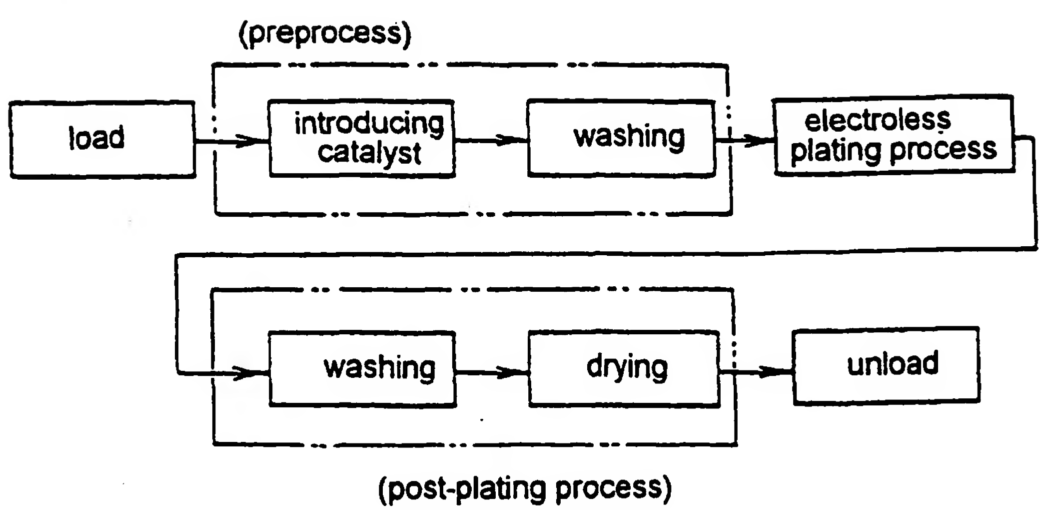
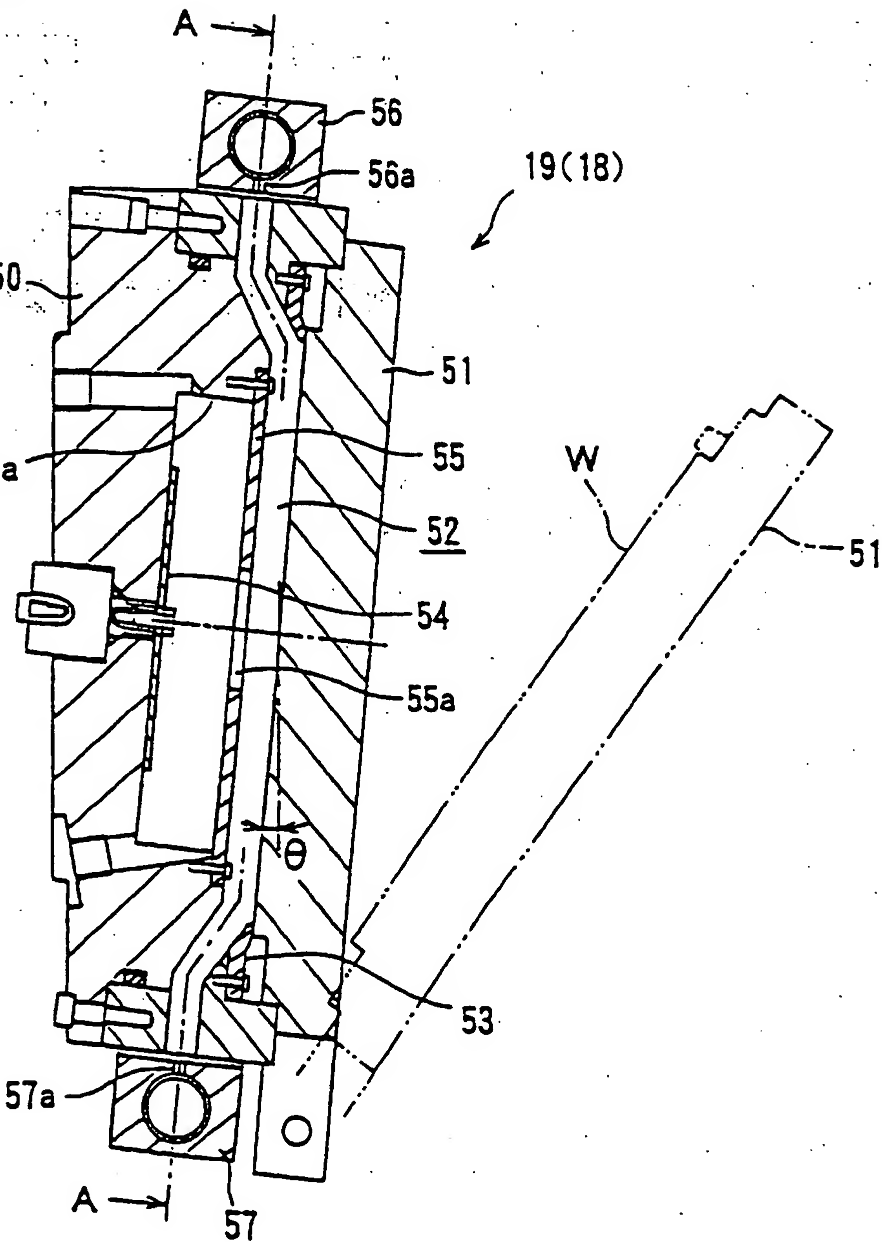

(preprocess)
load
introducing catalyst
washing
electroless plating process
washing
drying
unload
(post-plating process)

FIG. 6



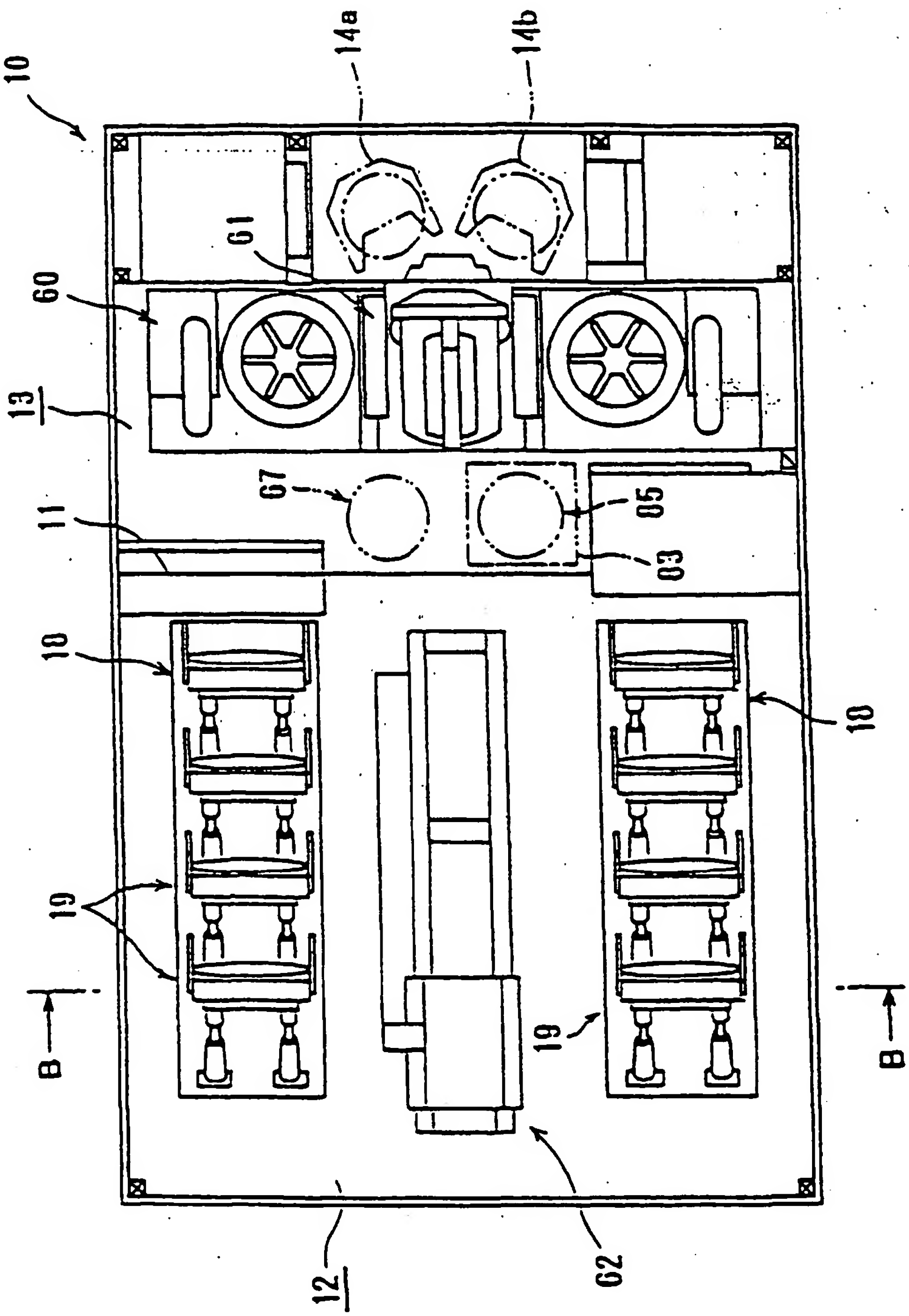
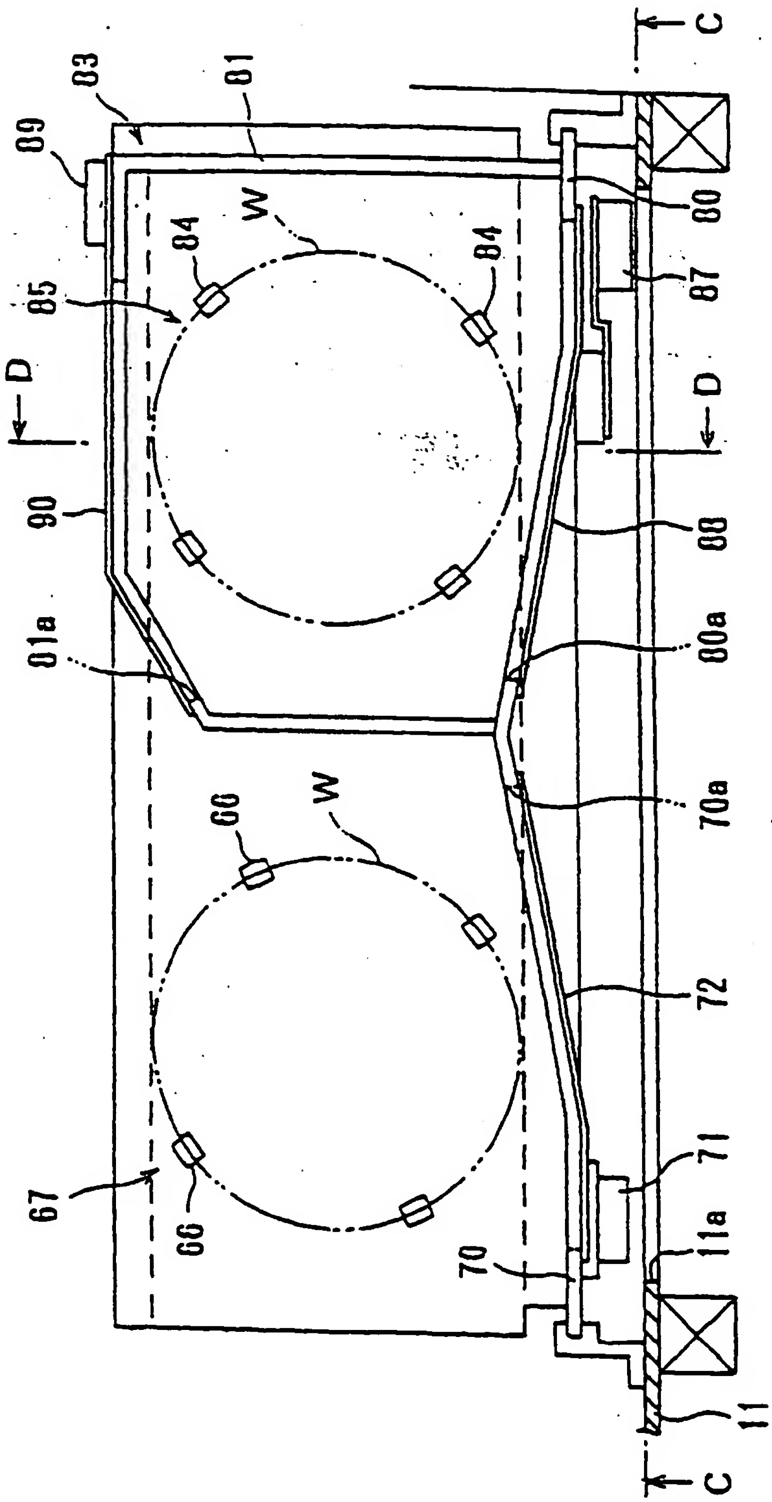


FIG. 8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83
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W
84
84
85
D
D
90
88
81a
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70a
W
66
66
72
67
71
11a
70
11
C
C
80
87

FIG. 10

FIG. 12

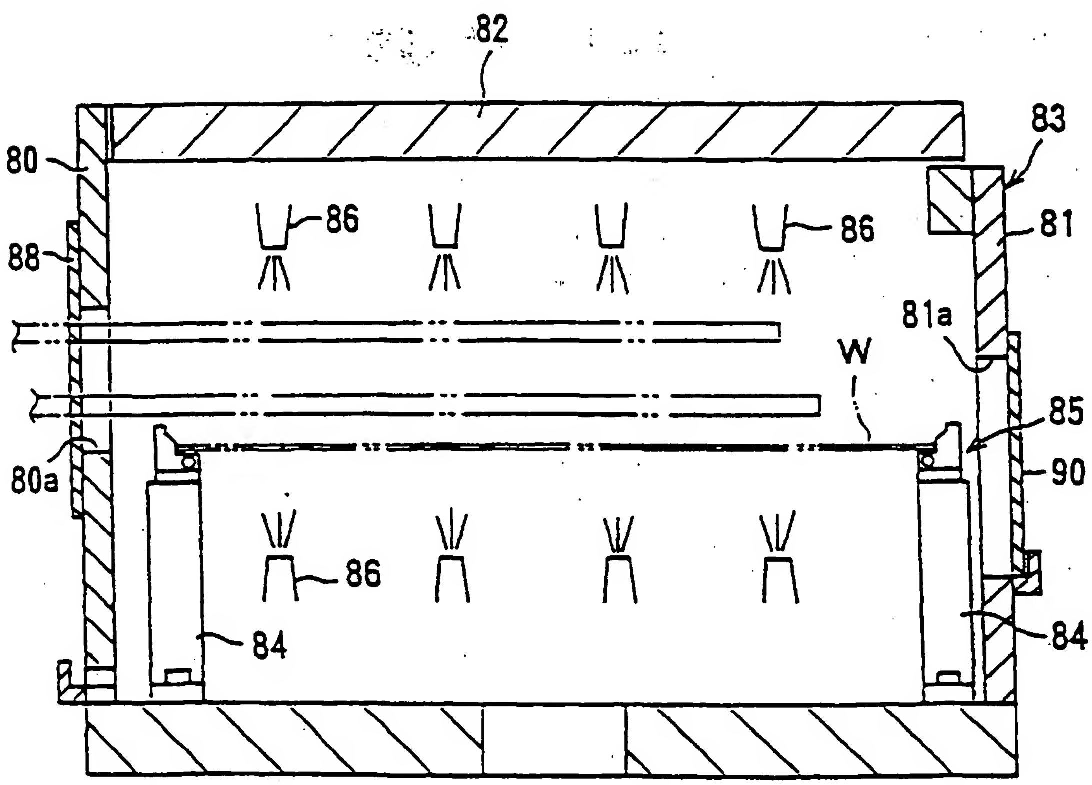
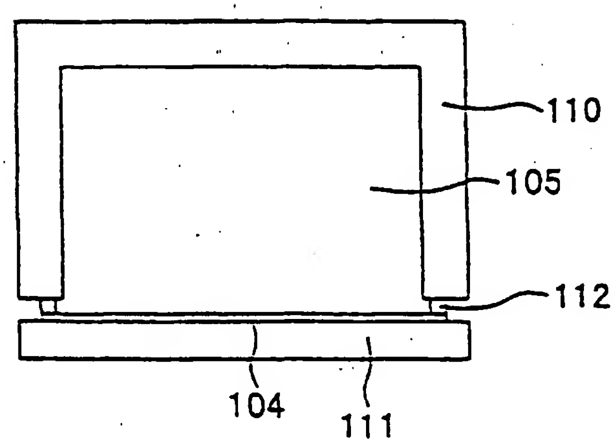
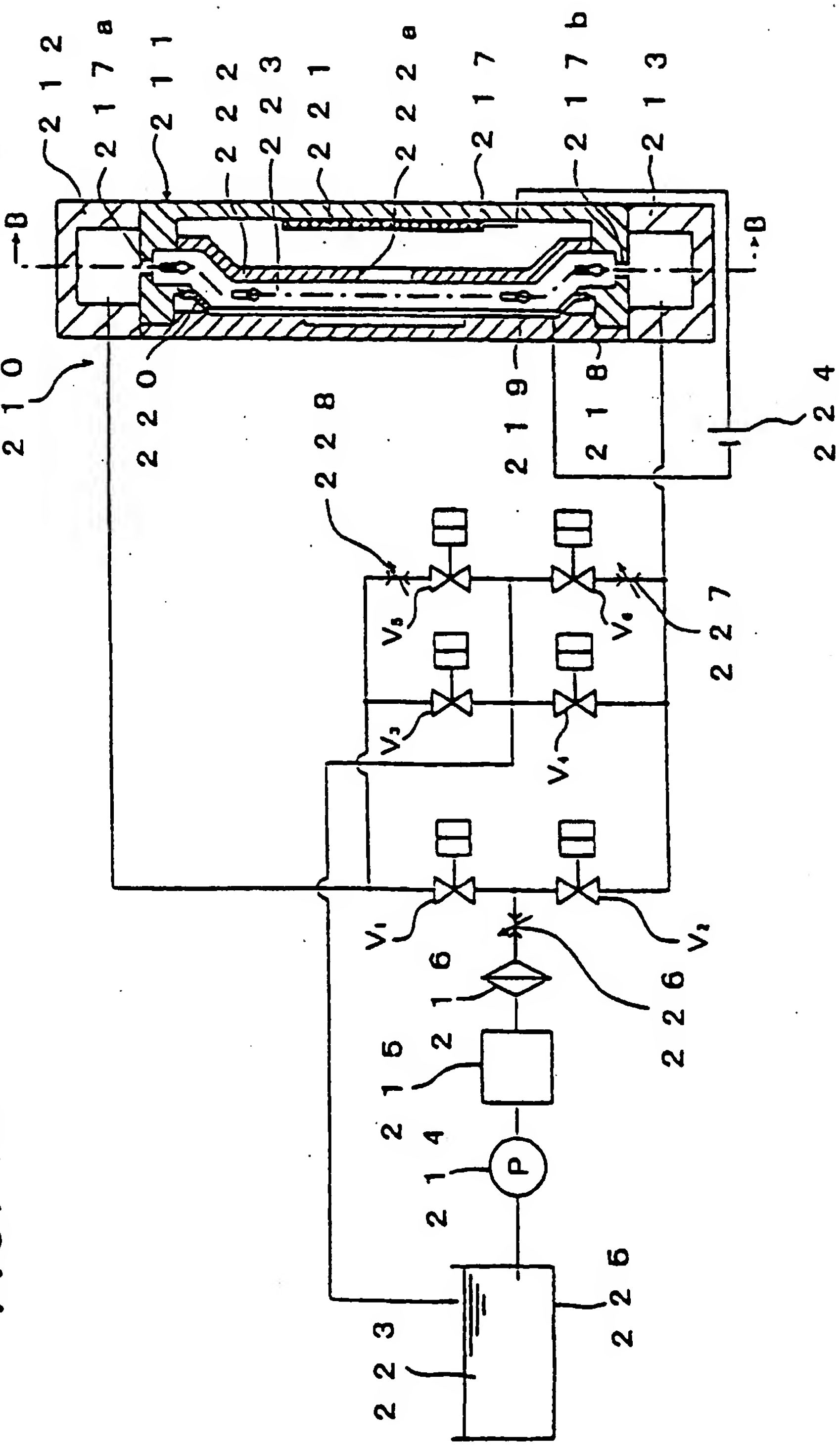


FIG. 14

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217a
217b
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222a
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226
227
228
V1
V2
V3
V4
V5
V6
P
B
B

FIG. 16

FIG. 18A

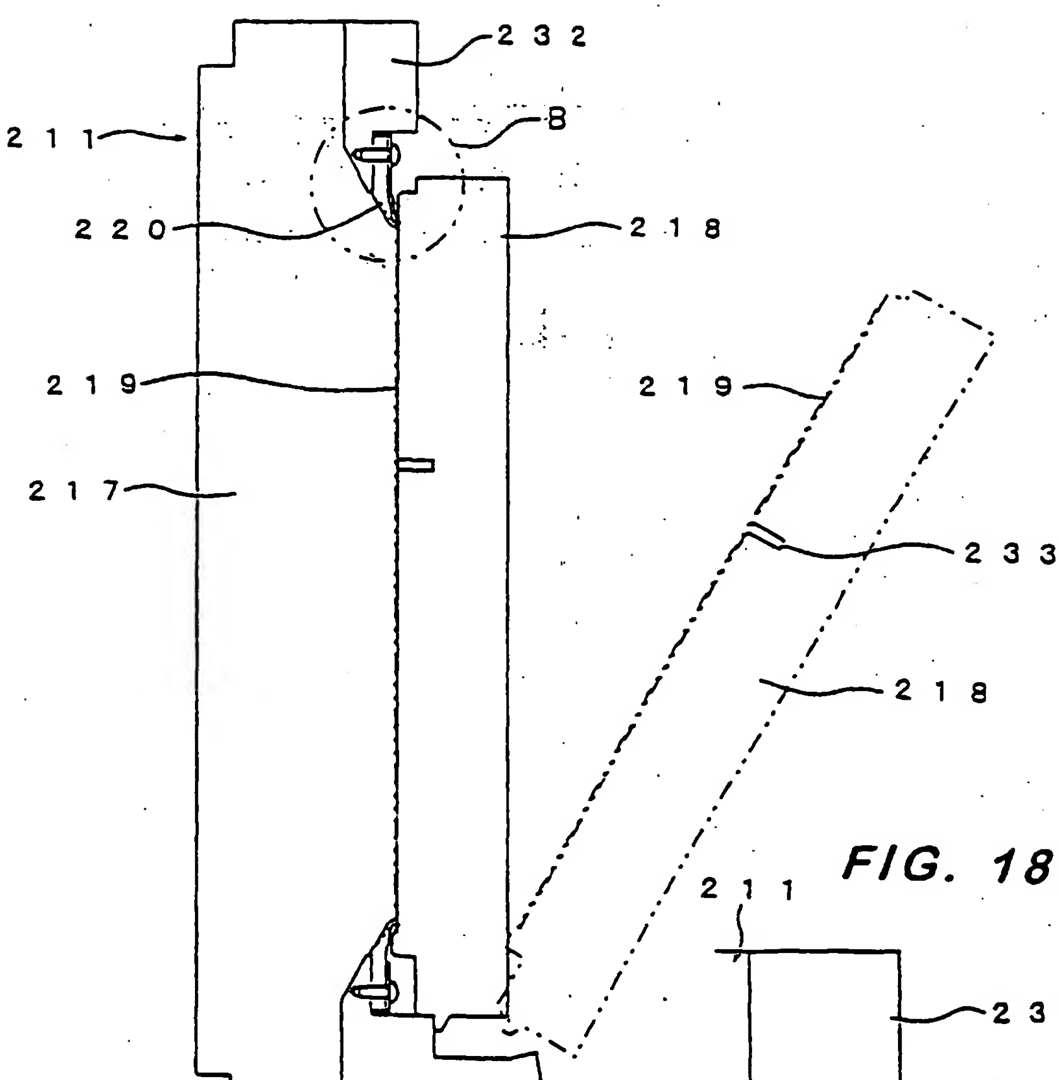


FIG. 18B

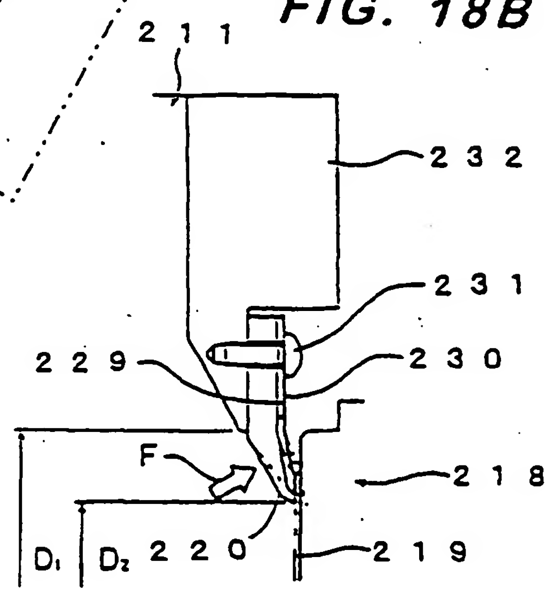
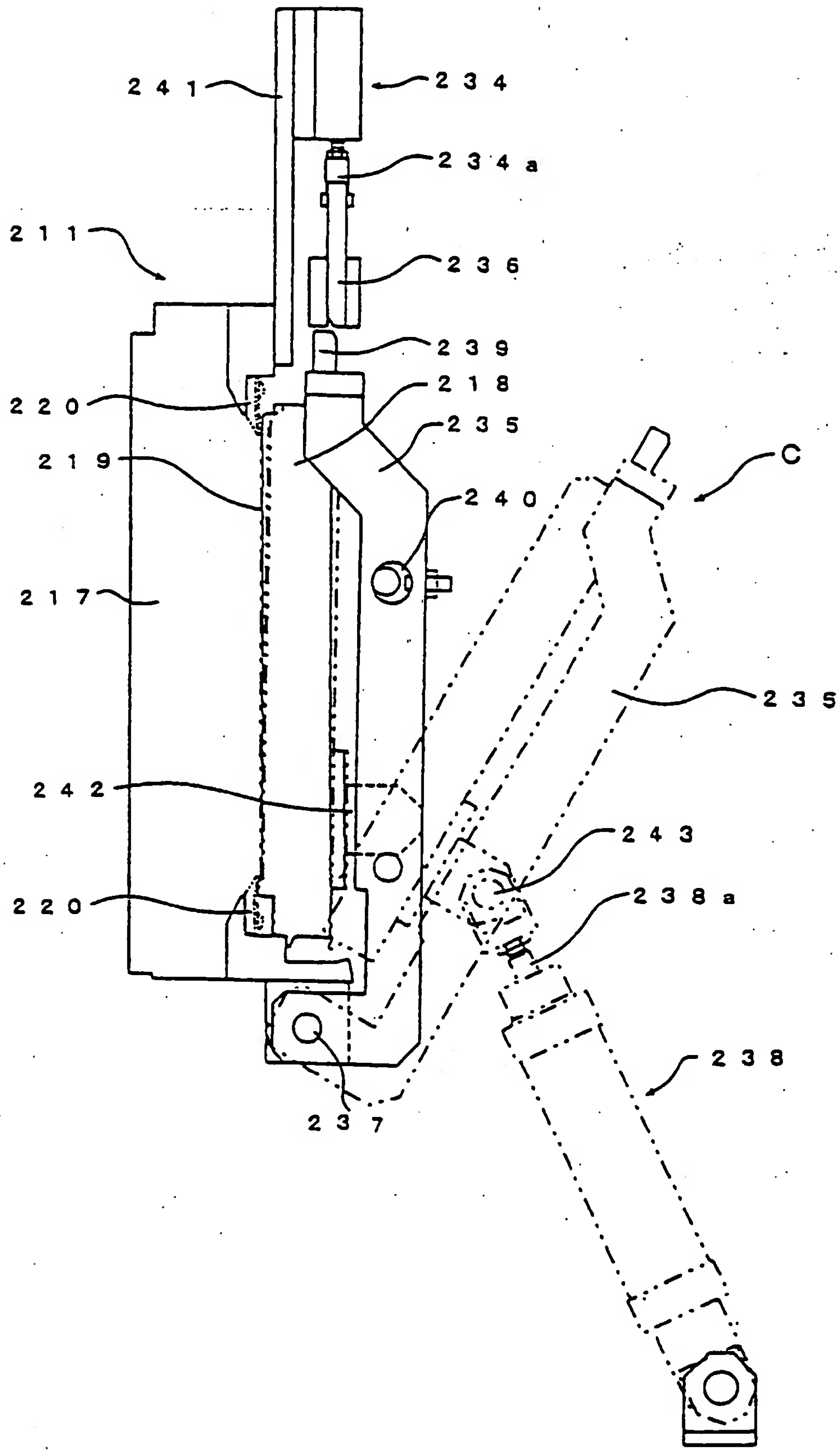


FIG. 20


241
234
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C
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243
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238a
238
237

FIG. 22

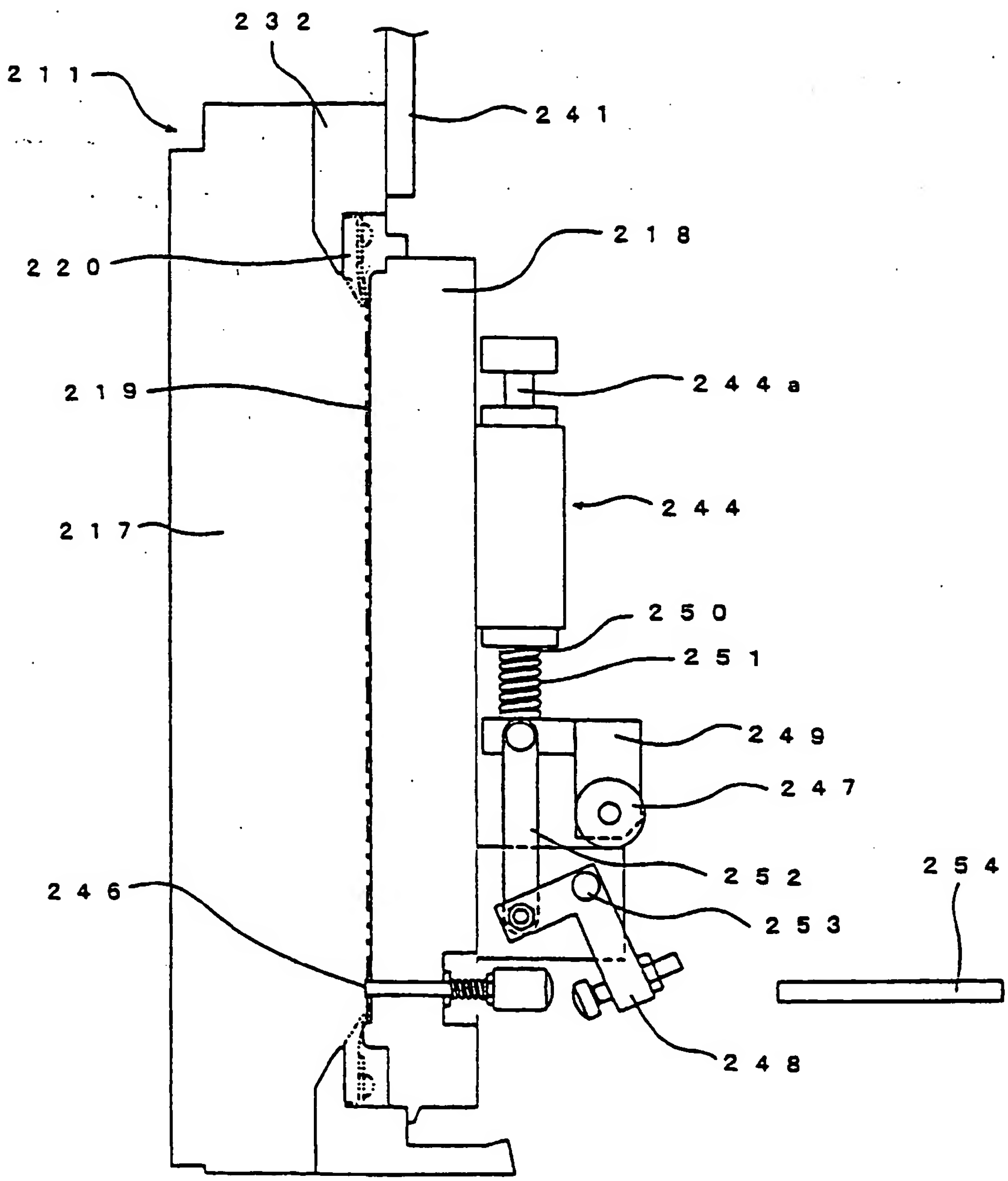
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FIG. 24

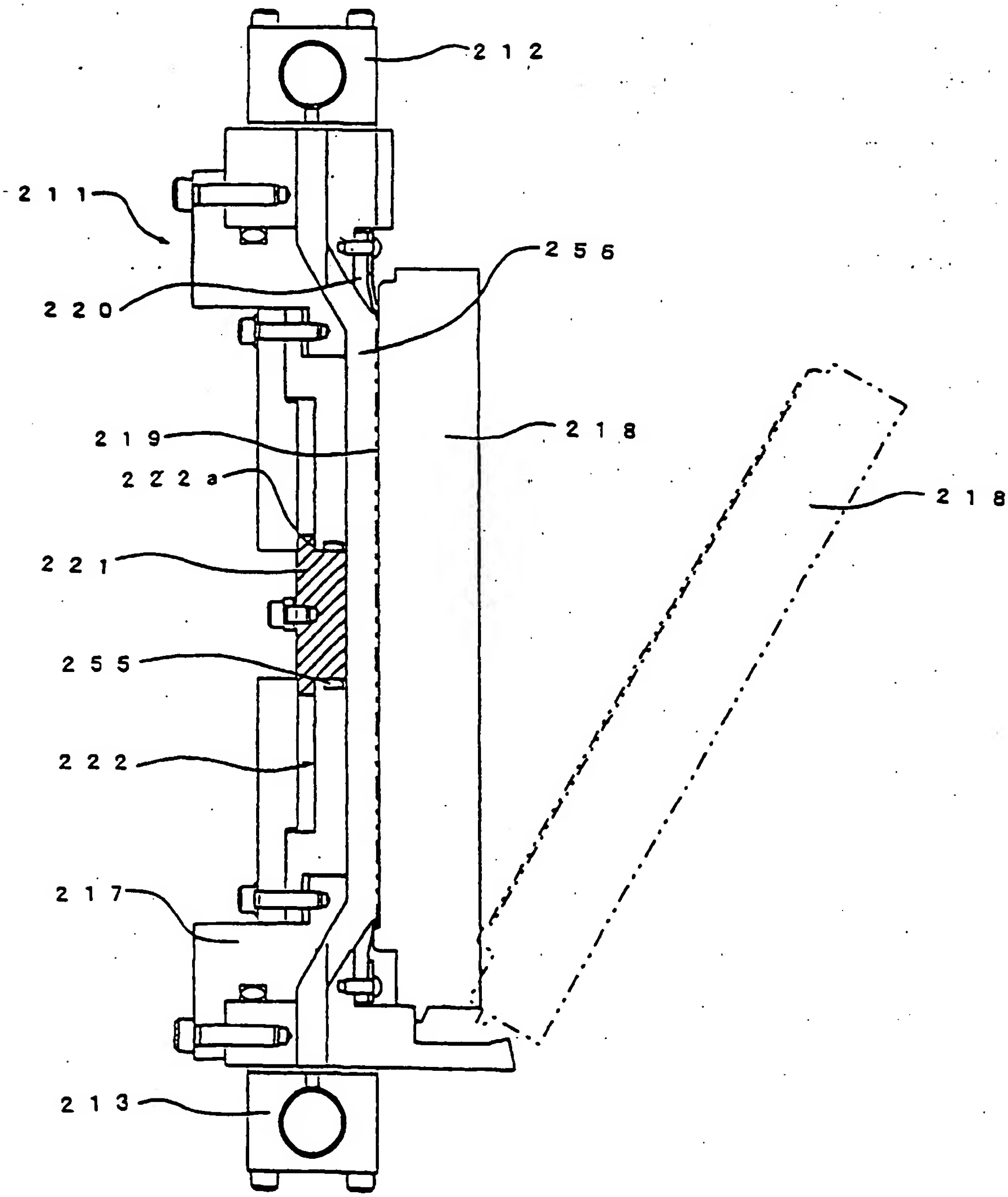
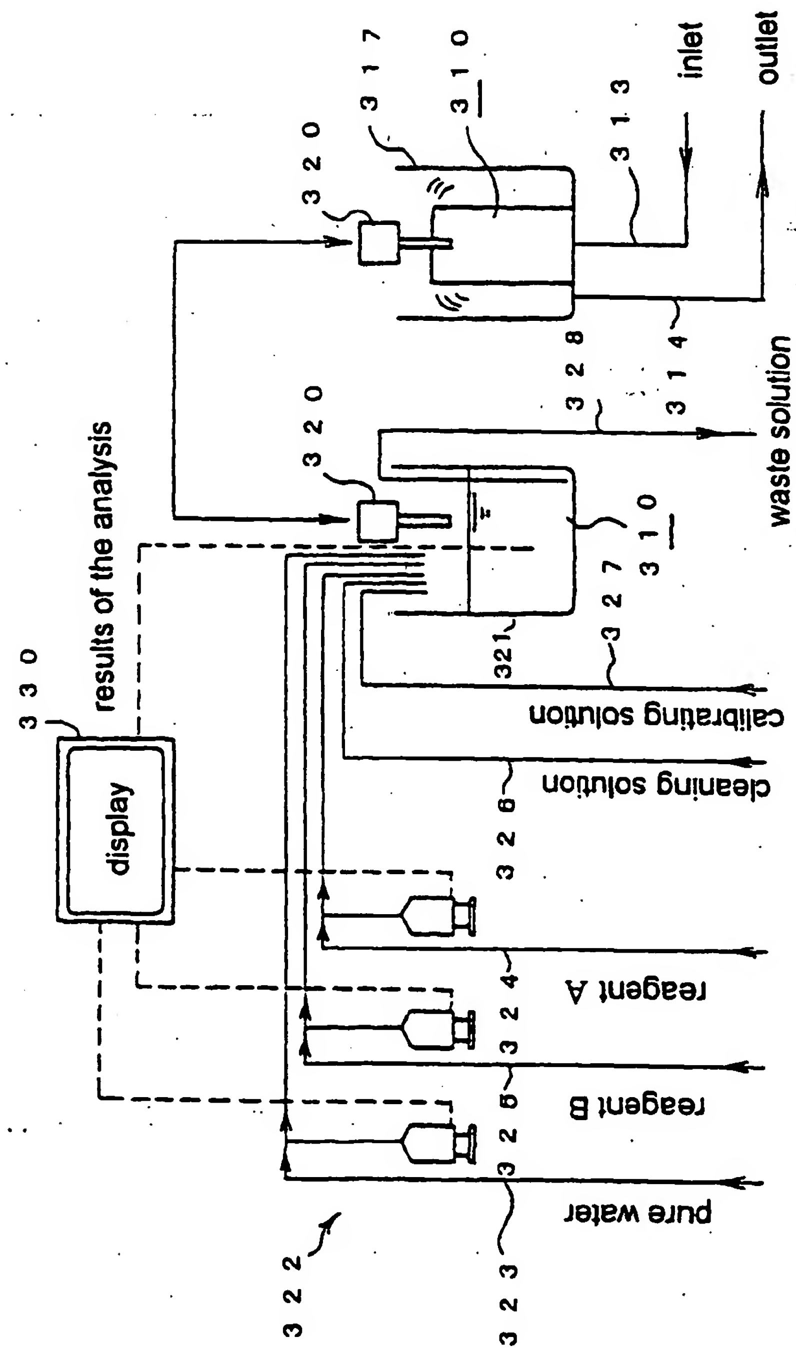


FIG. 26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display
results of the analysis
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outlet
328
314
waste solution
310
327
321
calibrating solution
cleaning solution
326
reagent A
324
reagent B
325
pure water
323
322

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/00994

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 6-57497, A (Casio Computer Co., Ltd.), 1 March, 1994 (01. 03. 94), Claims ; Fig. 1 (Family: none)	13-14
A	JP, 5-331651, A (Nippondenso Co., Ltd.), 14 December, 1993 (14. 12. 93), Claims (Family: none)	16-18